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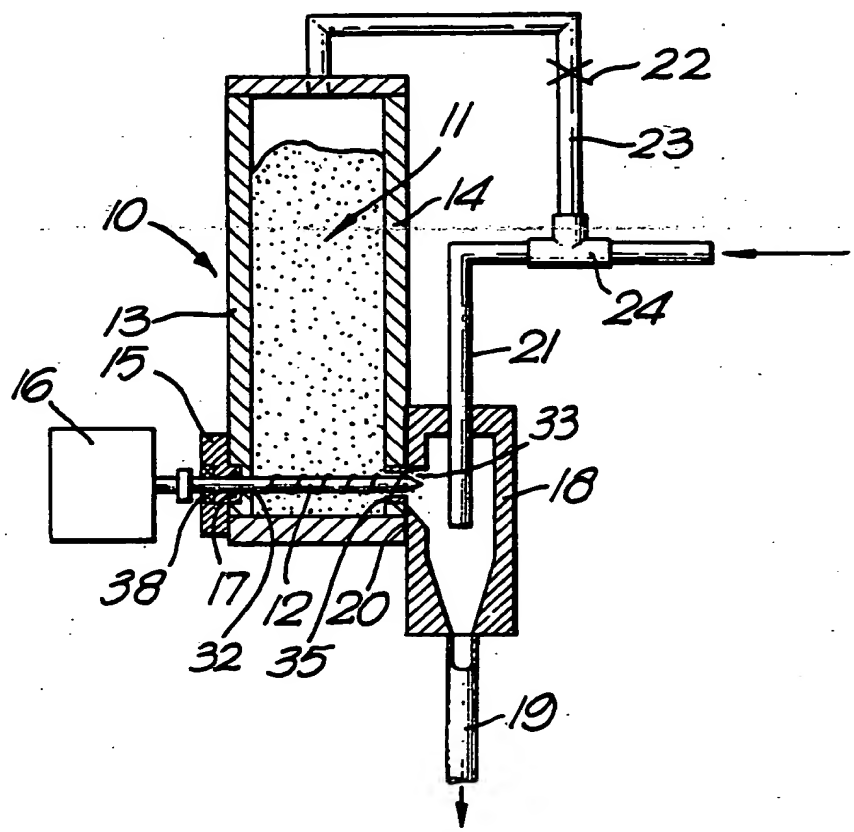
(57) Abstract

A screw powder feeder has a rotary screw (12) disposed at the base of a hopper (10). The screw (12) comprises a twist drill bit. Powder is discharged into a chamber (18) and picked-up by a flow of gas. The pressure in chamber (18) is varied relative to the pressure in hopper (10) to control the feed rate for a given screw speed. Ultra-low feed rates are made possible by feeding gas into the hopper (10) through the screw (12) and controlling the relative gas pressures such that the pressure in the chamber (18) exceeds the pressure in hopper (10).



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"SCREW POWDER FEEDERS"

This invention concerns the uniform feeding of irregular and regular shaped powder material at low mass feed rates.

There are many occasions on which solid powdered material has to be fed at uniform feed rates. These vary from pharmaceuticals and metal spraying to coal fired boilers and bulk food processing. In consequence numerous powder feeders are available based on a variety of principles, e.g. vibratory feeders, inverted weir and belt feeders, rotary disc feeders and screw feeders.

Nearly all these feeders have problems with "bridging" of the powder, particularly when irregular and/or very fine powders are to be fed. Screw feeders suffer from a further problem of "blinding" of the screw, whereby the powdered material rotates with the screw rather than being fed.

All feeders suffer from some form of slubbing of the mass flow. In certain processes, e.g. laser cladding with blown powder, this slubbing is of critical importance.

Providing a uniform powder flow at ultra-low feed rates is particularly difficult because, whatever the feeding mechanism, there is a conflicting requirement for a small aperture to achieve a low feed rate and a critical aperture to prevent "arching" of the powder, coupled with the additional requirement of high rotary/vibratory speeds to eliminate cyclic effects.

One object of the present invention is to provide a screw powder feeder which avoids, or at least reduces, screw "blinding" and "bridging" near the screw. The screw may then be rotated at higher speeds which in turn reduces the

observable slubbing effects.

Another object of the invention is to provide a feeder capable of uniform powder flow at lower feed rates than is possible with existing feeders.

A still further object of the invention is to reduce the cost of screw powder feeders.

According to one aspect of the invention, the screw in a screw powder feeder comprises at least two helical flutes, angularly spaced at 180° to one another.

In one particular embodiment the screw comprises a twist drill bit having a ridge along the leading or 'cutting' edge of the helical thread, the ridge normally helping to remove the swarf by providing some clearance against binding when the bit is used in a twist drill. Twist drill bits are inexpensive and widely available, thereby substantially reducing the cost of the screw feeder. Moreover, the long pitch of the flutes on a twist drill bit increase the "pumping" velocity parallel to the screw axis, thus giving extra momentum to the powder particles along the flutes in the required direction of feed. The outwardly projecting ridge which assists the powder feed by cutting through the powder and displacing it into the flutes effectively increases the "aperture" of the feeder for gravity flow.

In one possible alternative, the rotary screw comprises a milling cutter having four angularly spaced helical flutes at 90° to one another.

Ridged threads or finned threads over a short length of the screw may alternatively be used to assist displacement of

the powder into the groove or grooves.

The feeder may include a gravity feed hopper and, according to a further aspect of the invention, the feeding of powders which do not flow smoothly under gravity is assisted by discharging a gas into the powder in the vicinity of the screw, the quantity of gas being just sufficient to break down static arching of the powder at the outlet aperture of the hopper. The resulting dynamic arch collapse produces a uniform gravity flow on to the rotary screw which then conveys the powder into a discharge line.

The gas is preferably introduced into a longitudinal bore of the screw and emerges periodically at the surface of the screw through fine holes located in a predetermined sector of the screw and communicating with the bore, the gas being discharged only when the holes are facing upwards.

According to a still further aspect of the invention, the powder is fed under a predetermined pressure to the screw and discharged by the screw into a chamber, the pressure in the chamber being varied against the applied pressure to control the feed rate for a given screw speed. In this manner ultra-low feed rates can be achieved while still maintaining a uniform flow.

The applied pressure is preferably controlled by controlling the gas pressure in a gravity feed hopper. A relatively low hopper pressure increases "slip" by reducing friction between the powder particles and the screw surface and/or by inducing a backward flow of gas into the hopper.

The powder discharged by the screw is preferably picked up in the chamber by a gas stream, the powder being discharged

into an aerodynamically tranquil zone of the chamber before being entrained in the gas stream. The same gas supply may be used to pressurize the hopper through a valve located in a pressure equalising branch line disposed upstream of the chamber.

By way of example only, an embodiment of the invention is illustrated in the accompanying drawings, in which:-

Fig. 1 is a general arrangement of a screw powder feeder embodying the invention;

Fig. 2 illustrates one form of screw for use in the feeder of Fig. 1; and

Fig. 3 illustrates part of one alternative screw.

Referring to the drawings, a gravity feed hopper 10 feeds powder 11 to a screw 12 comprising a hardened steel twist drill bit with a pair of helical flutes 28 which are angularly spaced by 180° and intersect a conical point 34 to provide cutting edges of a specific rake. In the present case, however, the conical point is redundant and could be removed. A continuous ridge 30 around the leading or 'cutting' edge of the spiral screw thread 27 cuts through the powder as the screw is rotated and thereby displaces powder into the flutes. This action effectively increases the 'aperture' for gravity flow of the powder. It also assists in preventing binding or compression of powder in the flutes and improves the durability of the feeder. In one alternative arrangement shown in Fig. 3, the ridge 30 is replaced by fins 31 projecting from the screw thread 27.

The screw 12 is spaced just above the floor of the hopper,

and extends through aligned openings 32,33 in the opposed side walls 13,14. The two helical flutes 28 increase the number of 'pick-up' points compared to the number of such points in a conventional screw feeder having only one groove. One end of the screw is rotatably mounted in a bearing 38 located in a bearing housing 15 outside the hopper and is driven by a variable speed motor 16. An O-ring 17 provides a gas-tight seal in the opening 32 in side wall 13. The side walls 13, 14 are formed of a proprietary thermoplastic resin material so that, in use, fine particles of the powder 11 become embedded in the resin around the opening 32 to provide a continuous seal reinforcing the seal provided by O-ring 17.

The discharge end of the screw rotates within a bush 35 located in an outlet opening 33 in the side wall 14 and projects into a closed gas chamber 18 having a discharge passage 19. A gasket 20 seals the joint between chamber 18 and hopper 10.

Powder discharged by screw 12 into chamber 18 is picked up by a flow of argon gas delivered to the chamber through a delivery line 21. The metered quantity of powder is discharged into the chamber 18 in a non-turbulent region above the outlet of the delivery line 21, and is then entrained into the gas flow as it falls toward the base of the chamber.

A low uniform flow rate (e.g. 0.020 g/s for stainless steel powder of 300 mesh size) is achieved by suitably balancing the gas pressure inside the hopper 10 against the gas pressure in the chamber 18. This is achieved by pressurising the hopper through a needle valve or pressure regulator 22 connected in a pressure equalising line 23 which branches from the delivery line 21 at a T-junction 24

upstream of the chamber 18.

The powder flow is also controlled independently of the conveying gas flow by varying the screw rotation speed.

In the above design, the powder is fed initially on to the screw flutes by gravity. This would normally preclude uniform feeding of fine cohesive powders (say 10 µm) which do not flow smoothly under gravity. However, feeding of such powders is made possible by blowing gas, preferably a shrouding gas such as argon, through small holes 26 (Fig. 2) located in the thread 27 between the machined flutes 28 of the rotating screw 12. The holes 26 have a diameter of between 10 and 200 µm and communicate with a central blind bore 29 into which the gas is fed from either an external or an internal source. The holes 26 are located in only one sector of the screw, and a valving arrangement (not shown) ensures that gas is admitted into the bore 29 only when the sector containing the holes 26 is facing upwards.

The gas periodically emerging from the holes 26 breaks up static arch formation above the screw. The result is that the screw is uniformly gravity fed by way of dynamic arch collapse.

When using the above screw to feed fine cohesive powders, valve 22 is placed on line 21 and line 23 is connected into a special bearing housing similar to housing 15 which has rotary seals (not shown) to facilitate gas injection into the central bore of the rotary screw. In operation, valve 22 is fully open initially so that there is very little flow of gas through line 23 into the screw. Under these circumstances no powder discharge is usually observed because the particular cohesive powders do not flow under gravity onto the screw. Valve 22 is then progressively

closed to by-pass an increasing amount of gas into the screw through line 23 until at one point, and depending on the cohesiveness of the particular powder, discharge of powder is observed at 19. Valve 22 is then retained in this partially closed position.

With this arrangement, line 23 is no longer connected to the top of the hopper but another valve (not shown) is fitted onto the hopper lid and vents into the atmosphere. The pressure within the hopper is then regulated by using this valve.

In either case the pressure within the hopper is preferably less than the pressure in the chamber 18 to induce a backward flow of gas into the hopper which increases 'slip' by reducing friction between the powder particles and the screw surface and/or induces a backward flow of gas into the hopper.

Uniform loading of the rotating screw feeder is ensured by the balanced gas pressure across the feeder and can be further ensured by having steeply sloped hopper walls (not shown).

CLAIMS

1. A screw powder feeder comprising: a hopper for retaining a supply of powdered material, a rotary screw disposed at the base of the hopper for conveying predetermined quantities of the powdered material through an outlet aperture, and characterised in that the the rotary screw comprises at least two helical flutes angularly spaced by 180°.

2. A screw powder feeder according to claim 1 in which the helical flutes comprise the flutes of a twist drill bit.

3. A feeder according to claim 1 or claim 2 in which at least a portion of the helical thread formed by the flutes is provided with outwardly projecting means for directing or displacing powder into the flutes.

4. A feeder according to claim 3 in which the outwardly projecting means comprises a continuous ridge disposed around the leading edge of the helical thread formed by the helical flutes.

5. A feeder according to any one of the preceding claims in which the powdered material is fed under a predetermined pressure to the screw and is discharged by the screw into a chamber, the pressure in the chamber being varied against the applied pressure to control the feed rate at a given screw speed.

6. A feeder according to claim 5 in which the hopper is a gravity feed hopper and in which means are provided for introducing pressurised gas into the hopper to control the applied pressure.

7. A feeder according to claim 6 in which the pressure in the chamber exceeds the applied pressure in the hopper whereby, on extracting the powder, a reverse gas flow is induced to assist aeration and loosening of the powder being conveyed by the screw.

8. A feeder according to any one of the claims 2 to 7 in which the chamber has a first inlet communicating with the outlet of the hopper, a second inlet communicating with a source of pressurised gas, and an outlet through which the gas emerges, the powder discharged through the first inlet being entrained in the resulting flow of gas through the chamber.

9. A feeder according to claim 8 in which the first inlet is disposed upstream of the second inlet in an aerodynamically tranquil zone of the chamber.

10. A feeder according to any one of the preceding claims further comprising means for inducing local 'static arch breaking' of the powder in the vicinity of the screw.

11. A feeder according to claim 7 in which the 'arch breaking' means comprises means for periodically injecting a gas into the powder at predetermined locations along the screw.

12. A feeder according to claim 11 in which the injecting means comprises a longitudinal bore in the screw, a plurality of holes in the helical thread of the screw communicating with the bore, and means for admitting a gas into the bore.

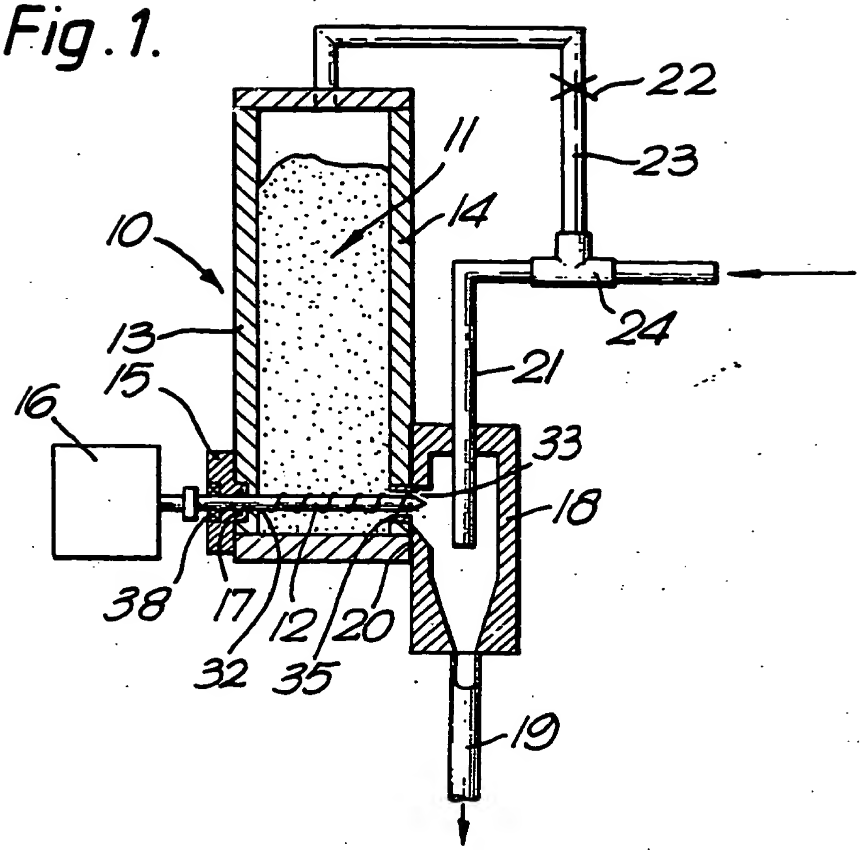
13. A feeder according to claim 12 in which the holes are disposed only in a predetermined sector of the screw, and

in which the admission of gas to the bore is dependent on the relative angular position of the sector in each revolution of the screw.

14. A feeder according to any one of the preceding claims in which the rotary screw extends through aligned openings in respective side walls of the hopper, the opening at the driven end of the screw being at least partially sealed by embedding of the powder particles in the hopper wall bounding the opening.

15. A screw powder feeder comprising a hopper for retaining a supply of powdered material, a rotary screw disposed toward the base of the hopper for conveying the powdered material at a controlled feed rate to a discharge chamber, means for directing a flow of gas through the chamber to entrain the powder discharged into the chamber, and characterised by means for inducing a reverse flow of gas from the chamber to the hopper to aerate or loosen the powder being extracted.

Fig.1.



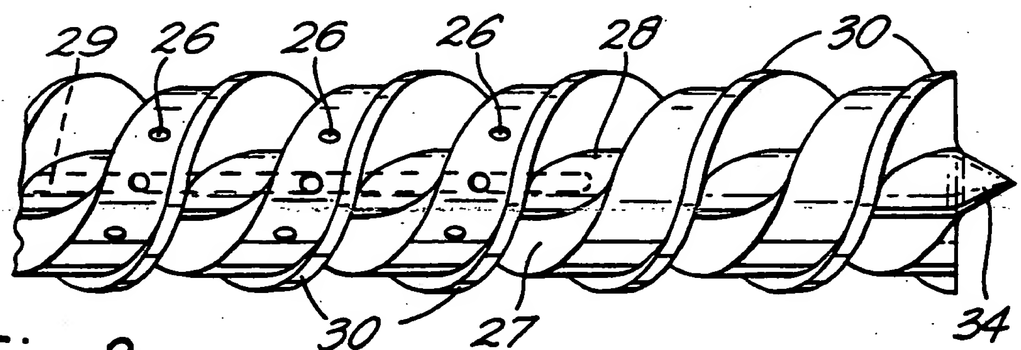
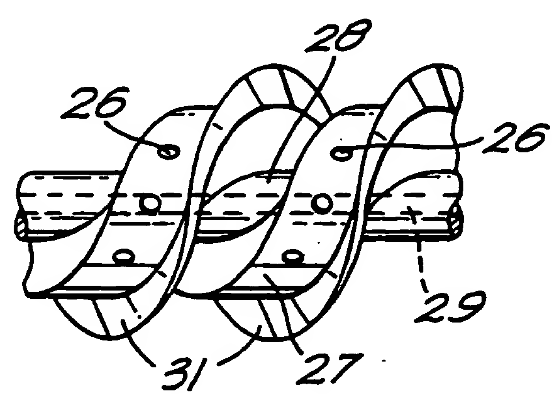


Fig.2.

Fig.3.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 85/00456

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: B 65 G 53/08; B 65 G 65/46; B 65 G 33/26

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	B 65 G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 2127693 (Mc CANLESS) 23 August 1938, see page 1, column 2, lines 10-25; page 2, column 1, lines 24-52; figures 1,2	1,8,9
A	US, A, 4077527 (FRYER) 7 March 1978, see figures	5,6,15
A	US, A, 3099496 (KAYSER) 30 July 1963, see column 3, lines 34-37; figure 4	10
A	FR, A, 2091891 (RASTOIN) 21 January 1972, see figure 1	11,12

* Special categories of cited documents: [10]
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
9th January 1986	29 JAN. 1986
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 85/00456 (SA 10943)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 21/01/86

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 2127693		None	
US-A- 4077527	07/03/78	None	
US-A- 3099496		None	
FR-A- 2091891	21/01/71	None	

For more details about this annex :
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